

STUDIES IN FRUIT DISEASES

III

DISEASES OF THE RASPBERRY

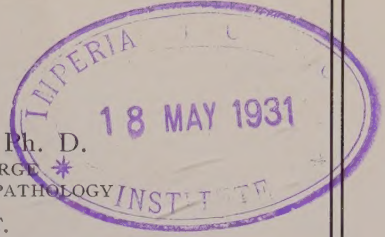
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DISEASES OF THE RASPBERRY

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MOSAIC AND LEAF CURL

During the last ten years the growers of raspberries have been confronted with a rapid "running out" of their plantations. In some sections this has been of so severe a nature that certain red varieties have been discarded by the grower as unprofitable. As a result of an investigation into this so-called "running-out," undertaken by the staff of the St. Catharines Laboratory of Plant Pathology in 1921, it was ascertained that two distinct virus diseases were responsible. These diseases are known to-day as mosaic and leaf curl.* These diseases have been known for some twenty-five years, but until 1921 were considered as one, under the term "yellows".

Distribution

Mosaic is found throughout Canada on wild and cultivated varieties. In Ontario it is now general on red, purple and black varieties. In the Niagara Peninsula and eastward along the northern shore of Lake Ontario, it is particularly severe, many Cuthbert plantings showing 100 per cent infection with the average around 15 per cent or 20 per cent. In the London and Waterford districts the average percentage of infection is around 10 per cent. In Quebec the Cuthbert shows infection up to 30 per cent. In Saskatchewan the Sunbeam, Herbert, King, Ohta and Miller have been reported as infected. In the Maritime Provinces the Herbert and Cuthbert have been reported as severely infected in some cases. In Manitoba, Alberta and British Columbia reports indicate that mosaic is prevalent on certain varieties.

In Ontario leaf curl is not so general in its distribution as mosaic but is severe in certain localities. In Quebec the Cuthbert variety is quite generally affected, often up to as high as 30 per cent.

Symptoms

Mosaic.—Mosaic symptoms are to be found on the leaves, and leaves only. The leaves do not dry up, wilt or fall, but rather take on a somewhat lighter colour than the normal green of a healthy plant. As the disease progresses, the leaves become mottled and dwarfed. This fine to coarse green mottling (fig. 1) is very faint in newly infected plants, but later becomes very distinct and the light-yellowish patches between the normal green of the leaf are very pronounced. The ratio between light-yellow and green varies greatly so that sometimes the dark-green spots are more numerous than the light-yellow and vice versa. In either case the characteristic symptom is that the normal green of the leaf gives place to light-yellow areas of varying size, giving the leaf

*Report of Dominion Botanist for year ending March 31, 1922.

surface a mottled appearance. Accompanying this mottling is generally a puckering or roughening of the leaf surface. This is particularly true of certain varieties such as the Columbian. The dark-green spots are generally raised above the mean surface of the leaf, resulting in a dull, uneven surface in contradistinction to the smooth, shiny, even surface of a normal leaf. One constant sign for identification purposes is that when a leaf on a shoot becomes mottled all the new foliage produced on that shoot develops the same characteristic mottling.

Mosaic symptoms as outlined are particularly noticeable on new growth, especially the suckers. In the early summer this is where the first signs of mosaic are apparent, and in making an inspection of a plantation look always



FIG. 1—Cuthbert leaf showing the characteristic mosaic mottling.

on the present season's growth. Inspections should start about the first of June, and be repeated at intervals throughout the growing season. When inspecting your raspberries for the presence of mosaic, walk down a row of raspberries, casting your shadow on the plants under observation, because under these conditions (shade) mosaic symptoms show up better on a very bright day. Great care must be taken with the inspection since the mosaic mottling in its early stages is easily overlooked on account of its indistinctness, and since success in control, from the rouging standpoint, depends almost entirely on taking out mosaic plants as soon as they become diseased, the value of careful and efficient inspection is apparent.

The symptoms on the different varieties vary somewhat. The mottling on all varieties when newly infected is rather indistinct. On Cuthbert, King and Newman 23, the mottling is generally fine, whereas with the Herbert, Marlboro and Viking varieties the mottling is often very coarse. Sometimes however, the Marlboro has a very fine indistinct mottling that is hard to diagnose.

There may be very little dwarfing noticeable the first year of infection, but thereafter dwarfing becomes gradually more pronounced each year (fig. 2). The fruit from dwarfed-mosaic bushes is greatly reduced in quantity and the berries are mostly soft, crumbly and insipid.



FIG. 2.—Dwarfed mosaic (left) and healthy bush (right). Note also puckering and slight curling of the lower leaves on the mosaic bush.

Leaf Curl.—As with mosaic, so with leaf curl, the symptoms of the disease are confined to the leaves. The leaves in this case are not mottled however, but are abnormally dark-green in colour and are wrinkled and curled. The curling on newly infected plants may be very slight but later the entire margin of the leaf becomes rolled downward and inward (fig 3). The fruiting laterals are short and usually stand upright. The suckers from a diseased bush of a previous year are dwarfed and terminate in a yellowish stunted tip. The fruit is dry and seedy and is not worth picking. Once a bush has become diseased, it is not only useless from the standpoint of production, but in addition, is a source of constant spread of infection to nearby healthy bushes.

Susceptible Varieties

The common commercial varieties grown in Canada are all susceptible to mosaic. In fact the writer knows of no variety that is absolutely immune to mosaic. There are, however, two varieties that show a high degree of resistance to mosaic under Ontario conditions. By resistance we mean that such varieties do not take mosaic to any extent, that is, they appear to escape infection. The Herbert variety is quite highly resistant. Most plantations of this variety will show no mosaic whatever, or at most rarely more than a trace. Adams 87, a new berry originated by Mr. Geo. Adams, Smithville, also shows



FIG. 3—Healthy plant (left) and leaf curl plant (right). Note rolling inward and downward of leaf surface.

promise of being resistant. This berry has just been put on the market and so its distribution is as yet quite limited. However, we have had this berry under observation for six years and so far it appears to be quite resistant. Time alone will tell if this apparent resistance is an actuality or not. From the standpoint of resistance to disease these two varieties stand out above all other varieties tested in Ontario.

Rate of Spread

In Ontario the annual spread of mosaic is not rapid. From demonstration and experimental plots, as well as in fruiting plantations, we have found the average yearly spread for the last five years to be around 4 per cent. This is not rapid, but is rather a slow but constant, unobserved spread that eventually succeeds in devitalizing the plantation; a case of the tortoise "slow but sure."

Leaf curl in the Niagara peninsula is now considered of minor importance, since the growers have been systematically roguing this disease for the past few years. There is therefore, little leaf curl present and hence spread is likewise small. In districts however, where strict attention is not paid to this disease the spread will be as great if not greater than with mosaic.

Manner of Dissemination

Observation and research has shown that both mosaic and leaf curl are spread by means of aphids, commonly called plant lice. That these insects are one of the agents which spread the mosaic and leaf curl disease, is entirely due to their feeding habits. They are sucking insects, and while passing from diseased to healthy bushes in the course of feeding, transmit the contagious principle which is contained in the plant juices.

Since all parts of a mosaic or leaf curl plant contain the infectious principle these diseases may also be spread by means of vegetative shoots (suckers, tips, root-cuttings), from diseased plants. It is for this reason that the use of healthy certified stock for planting purposes is so highly recommended. (See section on Certified Raspberry Stock.)

Economic Importance

It has already been pointed out that the so-called "running-out" of certain raspberry varieties is largely, if not entirely, due to mosaic, leaf curl, and similar diseases. Such being the case, it is at once apparent that mosaic and leaf curl are a serious menace to the profitable growing of raspberries in Canada.

In an experimental plot of thirty mosaic and thirty healthy bushes the total crop harvested from healthy bushes was 24,517 berries and from mosaic bushes, 18,664 berries, a reduction in yield due to mosaic of 5,853 berries. This clearly demonstrates that mosaic reduces the crop. According to our leading horticulturists the yield per acre from well cared for, healthy red raspberries should be in a favourable season, from 4,000 to 7,000 quart boxes.* Yet how many growers to-day are getting anything like this crop per acre? What is the reason for the low yields of to-day? Diseases, particularly mosaic and leaf curl, are the answer.

Generally speaking, plantations that contain considerable mosaic are by no means as productive as they should be. Since a bush once infected with mosaic or leaf curl, never recovers, and, in addition, since all such bushes left in the plantation become sources for increased infection and spread, the effect of these diseases upon the raspberry-growing industry is apparent. These two diseases therefore deserve the careful attention of every grower since they are without doubt the worst diseases of the raspberry and cause an annual loss of many thousands of dollars.

*Bush Fruits. Bull. 94, p. 29. Dom. Dept. of Agr.

Control

With infectious diseases of this type the first essential in control is a knowledge of the symptoms, etc., so that a grower may be enabled to diagnose the disease in the field. Success in mosaic and leaf curl control largely lies in the ability to identify these diseases in the young plantation and to rogue thoroughly.

In order that the raspberry-growers of Canada may become familiar with these diseases and the best methods of control, the Dominion Laboratories of Plant Pathology at St. Catharines, Ontario, Ste. Anne de la Pocatière, Quebec, and Charlottetown, P.E.I., maintain an inspection service, through which information is given free to the grower upon request. In the other provinces assistance will be obtainable by applying to the Dominion Laboratory of Plant Pathology situated within the Province.

Before giving the actual methods for control, it will be well at this point to recapitulate the following facts upon which the control measures are based.

1. Once a plant becomes infected, it never recovers.
2. All parts of the plant carry the infectious principle.
3. The mosaic symptoms are rather hard to diagnose.
4. Spread is brought about by plant-lice and vegetative parts such as suckers, tips, or root-cuttings.
5. These diseases are not carried in the soil provided roots of diseased bushes have been completely removed.

Bearing these facts in mind the reasons for the following control measures become at once apparent.

NEW PLANTINGS.—The most permanent and satisfactory control measures for mosaic and leaf curl begin with the setting out of healthy certified raspberry stock. Such stock has now been available in Ontario for the past six years as a result of the raspberry inspection and certification service carried on by the Dominion Laboratory at St. Catharines. Experiments with this stock have shown it to be in all respects satisfactory. Where such stock has been set out and has been carefully inspected, and diseased bushes rogued during the growing season, it has been found from three years' experience, that only a fraction of one per cent is now present. In many such plantations no more than 20 or 25 plants have had to be rogued during the past two years. Of course, where roguing has not been done, mosaic has increased to a much greater extent. Therefore in setting out a new plantation use only healthy certified stock. *Never use doubtful stock from a neighbour's plantings just because it costs you nothing. It is false economy.* This has been demonstrated time and time again.

Our experience with these diseases demonstrates that, although certified stock is the first essential in control, the roguing of diseased bushes during the first two seasons at least should by no means be neglected. Roguing has proved to be a valuable aid in mosaic control and we therefore strongly recommend its use in all plantings up to three years of age that contain a small amount of mosaic. This is particularly true for plantations set out with certified stock, where only a trace of mosaic will creep in the first year.

Therefore during the first season the young plantation should be carefully and systematically inspected several times by the grower and all diseased plants should be dug out, roots and all, and removed immediately from the plantation before the foliage has had time to wilt. If the bushes are allowed to wilt before removing, the aphids will have had a chance to pass from the wilted leaves to nearby healthy leaves and thus in place of effecting control, spread has actually taken place. In the removing of the bushes great care should be taken to see

that the diseased bushes are not dragged along the ground, or allowed to brush healthy plants, since the aphids which are feeding on the diseased plants, may be then knocked off to infect healthy bushes.

During the following seasons it is absolutely essential to continue careful inspections and roguing. Constant vigilance will be necessary to keep the patch free from disease. However, three years' experience has demonstrated that it can be done satisfactorily and with very little labour, provided the planting is started with certified stock.

OLD PLANTINGS.—An old plantation containing a considerable amount of mosaic should be ploughed up, or possibly let run until a new planting comes into bearing. It is not advisable to attempt to rogue a plantation over two years of age that has more than 5 per cent mosaic. A two-year-old plantation that has a small percentage of mosaic, may be put in a fairly healthy condition by careful and continued roguing.

In roguing (unless the bushes have just recently been set out, and are therefore some considerable distance apart in the row) it is advisable to rogue the healthy bush on either side of the mosaic in order that this apparently healthy bush may not act as a bridge to pass on the infectious principle to the next adjacent bush. Experience has repeatedly demonstrated the advisability of so doing. Rogued bushes should be carried carefully outside the plantation and burned.

Gaps, the result of roguing, may be reset with healthy stock at any time, provided all roots of the previous diseased bush have been removed. If such roots have not been removed, suckers will spring up therefrom which may infect the healthy reset.

New plantings of healthy stock should be isolated at least 320 feet from nearby wild or unrogued cultivated raspberries.

CERTIFIED RASPBERRY STOCK

During the past few years it has been repeatedly demonstrated that certified raspberry stock produces healthier and more productive plantations than does ordinary stock which will not meet certification requirements. For example, the average commercial plantation started from other than certified stock will have at least about 5 per cent mosaic to start with. This is a very conservative figure because many such plantations have in their first year 20 per cent and 25 per cent, and we have found a few that were 100 per cent infected with mosaic and leaf curl. In five such plantations the following average increase of mosaic has been recorded.

1923.....	4.0 per cent
1924.....	12.5 per cent
1925.....	24.0 per cent

On the other hand, the average increase in seven plantations where certified stock was used, was as follows:—

1923.....	0.5 per cent
1924.....	0.75 per cent.
1925.....	1.30 per cent.

The highest percentage of mosaic found in a plantation of certified stock after three years was 4 per cent (no roguing in this case) while in some the amount of mosaic actually decreased due to careful roguing. This shows the high superiority of certified stock over the average uncertified stock.

WHAT IS CERTIFIED STOCK?

Raspberry plantations that are in good general health, are situated at least 320 ft. from nearby wild or cultivated raspberries, and are found to contain not more than 2 per cent mosaic and leaf curl at time of first inspection are possible sources of certified stock. Following first inspection, however, such plantations to become certified must be carefully rogued by the grower in the manner recommended so that at the time of second inspection, no more than $\frac{1}{2}$ of one per cent mosaic is present. If more than $\frac{1}{2}$ of one per cent mosaic is present at time of second inspection, the plantation cannot be certified.

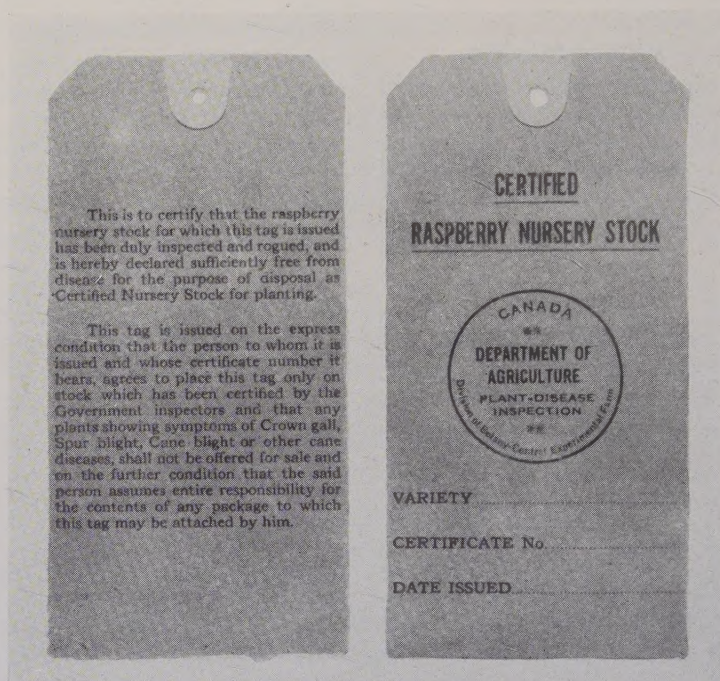


FIG. 4.—The official red tag to be used with certified stock.

Beginning with the season of 1930, all certified raspberry stock will in future be accompanied by an official tag (Fig. 4) designating the stock which it accompanies as “certified raspberry nursery stock.” All such tags will have the certificate number of the grower who produced the stock, and on the reverse side is stated:—

“This is to certify that the raspberry nursery stock for which this tag is issued has been duly inspected and rogued, and is hereby declared sufficiently free from disease for the purpose of disposal as Certified Nursery Stock for planting.

“This tag is issued on the express condition that the person to whom it is issued and whose certificate number it bears, agrees to place this tag only on stock which has been certified by the Government inspectors and that any plants showing symptoms of Crown Gall, Spur Blight, Cane Blight or other cane diseases, shall not be offered for sale and on the further condition that the said person assumes entire responsibility for the contents of any package to which this tag may be attached by him.”

STEPS NECESSARY TO OBTAIN CERTIFICATION

Any commercial grower of raspberries may have his plantation inspected upon making request to the Dominion Botanist, Ottawa, or to the officer-in-charge of the Laboratory of Plant Pathology for the Province in which he lives. This service is free. Whether or not a plantation is fit for certification depends entirely upon the percentage of mosaic and leaf curl found at time of first inspection. If more than 2 per cent mosaic or leaf curl is found at time of first inspection, the plantation cannot be certified.

A grower who is desirous of making a start at growing certified stock for planting purposes is urged to secure certified stock to start with and to carefully rogue all diseased bushes as they appear. Then make application for Government inspection. The most satisfactory way of producing "certified stock" is to grow the plants close together in a nursery row with the idea of using year old plants. Much better stock is secured in this way since inspection and roguing operations are simplified, resulting in greater freedom from disease. We strongly recommend the nursery row method of production of certified stock in preference to securing stock from fruiting plantations. The nursery row method is equally satisfactory for the grower who is desirous of growing a small quantity for his own plantings as well as for the grower who desires to produce certified stock on a large scale as a commercial proposition.

REGULATIONS GOVERNING CERTIFICATION

1. All certified stock sold is to be accompanied by the official tag.
2. Plantations of certified stock must be at least 320 feet from nearby wild or cultivated raspberries.
3. Mixed plantations cannot be certified.
4. Plantations to be certified must be vigorous, reasonably free from weeds, and generally well cared for.
5. Two inspections by authorized inspectors must be made of the plantation while in leaf. A third inspection where possible, is to be made at time of digging to ascertain the prevalence of crown gall and cane diseases.
6. All plants affected with mosaic or leaf curl are to be rouged immediately following first inspection, if not sooner. In roguing, the healthy plant on either side of the diseased plant should also be taken out. An exception to this rule is made in the case of a newly set out plantation where the plants do not as yet touch each other.
7. The producer of certified stock is held responsible for all stock to which his certificate number is attached.
8. All stock sold as "certified stock" must be true to name, of good vigour, and packed so that it will arrive at its destination in good condition.

STANDARDS FOR CERTIFICATION

INSPECTIONS.—At least two inspections, in some cases three, made in the field by a properly trained and authorized inspector. The first inspection to be made in June or early July. Second inspection to follow within a month. In so far as possible, a third inspection at time of digging will be made to ascertain the presence of crown gall and cane diseases.

DISEASES.—At first inspection not more than 2 per cent virus diseases. At last inspection, only a trace, up to $\frac{1}{2}$ of one per cent virus diseases allowed. No more than $\frac{1}{4}$ of one per cent Crown Gall at digging time.

STOCK.—Only first grade, well-rooted plants, practically free from virus, cane and crown gall diseases. For shipment, stock should be protected from drying out and satisfactorily packed and handled.

TO THE PURCHASER OF CERTIFIED STOCK

As soon as the plants arrive, set them out, or if not ready to plant, heel them in carefully. Do not allow the roots to dry out. Protect the roots from the wind when planting. After planting, be very careful with inspections for, and roguing of, diseased (mosaic and leaf curl) bushes. See section on Control of "Mosaic and Leaf Curl."

FOR NEW PLANTATIONS—USE CERTIFIED STOCK

Certified stock was developed in an attempt to check the spread of mosaic and leaf curl diseases by making obtainable for planting purposes a source of raspberry nursery stock that was practically free from "virus" diseases, true to name and superior as to general health. Experience during the past few years has demonstrated that certified stock has more than justified its existence. Yet certified stock is not in as great demand to-day as its merits justify. To anyone setting out a new raspberry plantation we highly recommend "certified stock" as being the only satisfactory means of curtailing mosaic and leaf curl diseases, that is available to-day.

ROSETTE, OR BRAMBLE STREAK OF THE BLACK RASPBERRY

This is an infectious disease similar in many respects to mosaic and leaf curl, but found only on black raspberries. The disease has been extremely severe in the Eastern and Middle Western States, but thus far the writers have observed but two plantations in Ontario. During inspections around Brockville in 1925 a small plantation of black raspberries was found badly affected with this trouble. The bushes were stunted. The leaves of diseased plants were slightly curled, and were crowded very closely together giving a Rosette appearance. The leaves were very faintly mottled as with mosaic. No pronounced discoloration or spots were noticeable on the stems, as is often associated with this disease in the Eastern States. In 1926 a plantation was found at St. Catharines, which was severely attacked by this disease.

Control

The same control measures as outlined for mosaic and leaf curl, apply here.

The Dominion Laboratory of Plant Pathology, St. Catharines, would be very glad to receive from raspberry growers, any reports of the suspected presence of this disease on black raspberries.

VERTICILLIUM WILT

Caused by *Verticillium ovatum* Berkeley and Jackson.

The diseases previously described (mosaic, leaf curl and rosette) are all of the virus type, the cause of which is not definitely known, whereas "wilt" is a fungous disease caused by *Verticillium ovatum*, Berkeley and Jackson.

In 1923 this disease was reported by the authors on red raspberries, under the title "Blue Stem of the Red Raspberry."* It is now considered advisable to use the term "wilt" since "blue stem" is the term commonly applied to a disease of raspberries of the virus type, known as Eastern Blue Stem, or Rosette. Moreover, since the striking characteristic of this disease is a yellowing, drooping, and "wilting" of the leaves, it seems more appropriate to use the term "wilt."

This disease has been found throughout Ontario during the past three summers on the following varieties:—

Red raspberry—

Cuthbert
St. Regis
Marlboro
Viking
Herbert

Black raspberry—

Cumberland
Gregg
Plum Farmer.

Other varieties are likely to be equally susceptible; this has, however, not yet been determined, largely due to their being so little grown in Ontario.

During 1923 several plantings of black raspberries were observed which had around 40 per cent infection. Red plantings this same year showed as high as 20 per cent infection. In 1924 and 1925 the disease was not so severe on red varieties although about the same on black varieties.

On black raspberries "wilt" is particularly severe; the authors have seen several cases where it was present to such an extent that it was considered advisable to discard the plantation. On red raspberries the disease does not appear to be so severe, yet cases have been observed where great damage was done and since "wilt" is now present throughout Ontario it would seem to be good policy for every grower to get familiar with this comparatively new disease.

Symptoms

RED RASPBERRIES.—The disease first becomes apparent in the field by a yellowing and wilting of the lower leaves. These leaves then droop and fall. (fig. 5). This wilting and casting of the leaves progresses from the ground upwards. As a result the cane finally becomes devoid of leaves, with the possible exception of a tuft of small brownish leaves at the extreme tip. This tuft of terminal leaves sometimes adheres for a considerable period. (fig. 6).

Generally accompanying this wilting and casting of the leaves is a blue discoloration of the cane, hence its former name "blue stem." This discoloration may be present as stripes starting from about the ground line and closely following the upward progress of defoliation, or the discoloration may cover the entire circumference of the cane. Canes have been observed with continuous stripes up one side, or both sides, or completely girdled by the blue discoloration. On the other hand numerous diseased canes have been observed which have shown no signs whatever of the blue discoloration, although they had

*First reported by the authors at annual meeting of Canadian Phytopathological Society held at Queen's University, Kingston, 1923, and later appeared as an abstract in *Phytopathology*, Vol. 14, p. 347, 1924.

been defoliated for some time. The blue discoloration, although generally present, may be wanting. The important, striking and constant symptom is therefore a yellowing, wilting and casting of the leaves.

In late fall and winter the presence of wilt may be ascertained by the presence of dead canes. Of course, all dead canes are not necessarily due to "wilt," but in a plantation where "wilt" has been prevalent dead canes are plentiful.



FIG. 5—Early stage of wilt. Note the curled and wilted leaves.

Canes that have gone into the winter condition apparently healthy although recently infected with this disease may be (1) killed, so that the buds will not unfold in the spring, (2) may be partially killed, so that only the buds on certain sections will unfold, or (3) may leaf out quite normally in which case the leaves and laterals are dwarfed and any fruit formed is small and tasteless. More often such canes lose their leaves and die before fruiting time.

BLACK RASPBERRIES.—On black raspberries the disease is much the same as described for red varieties with the exception that the blue discoloration is more pronounced, and generally girdles the cane. Sometimes the first indication is a premature drying of the fruit. Black varieties are much more susceptible to this disease, and a plantation of such varieties more readily succumb than the red variety due no doubt in part to the fact that the black varieties do not sucker.



FIG. 6—Later stage of wilt, showing almost complete defoliation.

That is, once a black variety takes this disease, since it is a root as well as shoot disease, the plant as a whole becomes infected and is eventually killed. In suckering varieties, however, new shoots may be sent up some little distance away from the parent plant, which therefore may escape infection, at any rate for a time. That such is actually the case has been observed commonly in the field.

Distribution

Cases have been noted where every cane in a hill was diseased and where eventually the whole hill was killed. With the black varieties this is generally the final result of infection, but with the red varieties it is rather unusual. In general the disease on red varieties is not so severe and although some, or all of the canes may be killed, new shoots arise from the underground roots that escape infection.

In 1923 three large plantings of red varieties had as high as 20 per cent infection. In 1924 and 1925 only a trace of wilt could be found, although the grower made no effort whatever to effect control. However, considerable financial loss resulted from (1) the loss of crop from fruiting canes of the current year, (2) the reduction of fruiting canes for the next year, and (3) in a general lessening of the vitality of the bushes making them more susceptible to winter injury and other diseases.

In other cases the disease has been present more or less each year. In general, however, it appears that "wilt" is more severe on plantations up to four years of age.

Since "wilt" is found now throughout Ontario on black and red varieties, causing considerable yearly loss and moreover since the disease appears to be on the increase, all growers are advised to become familiar with it.

A Fungous Disease

This "wilt" of raspberries is caused by a fungus known as *Verticillium ovatum* Berkeley and Jackson,* which belongs to a group of fungi usually associated with the wilting of many different plants and generally found in the soil. It is thought that the fungus first gains an entrance to the plant by way of the rootlets or root-hairs, and then grows upward into the canes, laterals and petioles, directly clogging the water-conducting cells and materially affecting the flow of water in the plant; and wilting results. (fig. 7).

Control

Since this is a comparatively new disease, very little is known as yet concerning definite control measures. However, from our present knowledge of the fungus causing this disease, we would strongly advise as follows:—

(1) Set out healthy, certified stock that has come from plantations free of this and other diseases.

(2) Do not set such plantings into soil that has just previously been planted to potatoes, tomatoes, or egg-plants (particularly if these crops showed any signs whatever of "wilting") because these crops are subject to the same wilt disease as raspberries and therefore if raspberries follow one of these crops, wilt may almost certainly be expected in the new setting. It has been the experience of many growers that under such conditions wilt very often became prevalent in the raspberry plantation. Of course, if the previous crop of potatoes, tomatoes or egg-plants was healthy then it would be safe to follow with raspberries.

**Verticillium Wilt of the Red Raspberry*—Berkeley, G. H., and Jackson, A.B., in "Scientific Agriculture," Vol. 6, No. 8, April, 1926.

(3) Since the fungus is able to live over in the soil, practise a four or five-year crop-rotation taking into consideration that potatoes, tomatoes and egg-plants are subject to this same disease.

(4) It is not advisable to plant potatoes, tomatoes or egg-plants between rows of raspberries as "wilt" may be thus introduced.

Resistant or immune varieties will probably offer the best means of control.

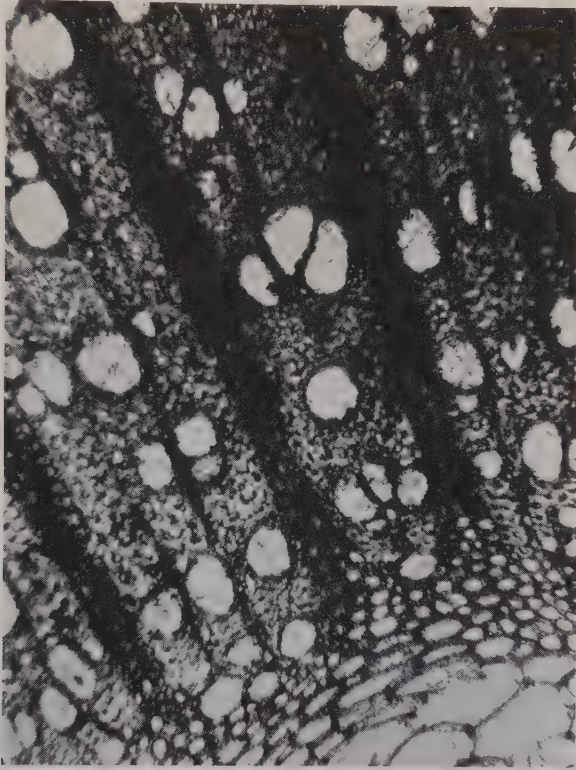


FIG. 7—A cross-section of a piece of raspberry cane, showing the mycelium (the thread-like strands in the open spaces) clogging the wood vessels.

SPUR BLIGHT

Caused by *Didymella applanata* (Niessl) Sacc.*

This is also a fungus disease and is apparently becoming more prevalent each year. In Quebec spur blight is quite general in the raspberry growing sections. In Ontario spur blight is severe in wet seasons, particularly on the Herbert variety, although all varieties are affected to some extent. Until recently it was thought that spur blight was of no great importance in Ontario, but recent research work has shown us definitely that spur blight is responsible for considerable loss of crop in Ontario.

*In North America the fungus causing spur blight of raspberries has passed under the name *Mycosphaerella rubina* (Pk.) Jacz. Unpublished work by Mr. L. W. Koch of this Laboratory has shown that the correct name is *Didymella applanata* (Niessl) Sacc., as paraphyses are present in many of the perithecia. Spur blight in North America is therefore identical with the disease as it occurs in Europe.

Symptoms

(a) ON THE CANES.—The earliest symptoms of spur blight are brown to violet-brown discolored areas, which are generally found on the lower halves of new canes directly surrounding the point of attachment of leaves. (Fig. 8.)

On the fruiting cane this disease is apparent as a grayish colouration with numerous tiny black bodies appearing on the gray surface of the cane. These black bodies contain the spores of the fungus that cause infection early in the spring. That is, the brown discolouration on the new cane gives way in September to a grayish discolouration followed later by a production of the winter spores as stated above. On the brown areas throughout the summer, summer spores are also produced.

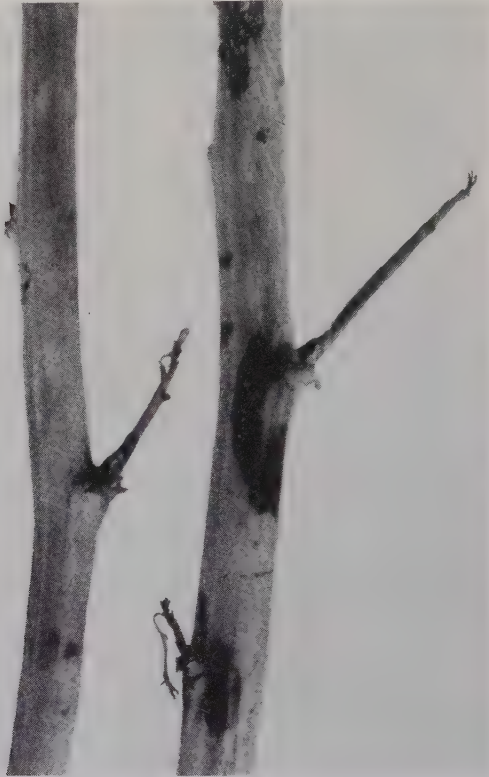


FIG. 8—Spur blight on the cane (photo by L. W. Koch).

(b) ON THE LEAVES.—Spur blight also causes an infection on the leaves, where it produces brown lesions which are generally associated with the main veins of the leaf. (Fig. 9). These brown lesions later turn black, and affected leaves drop to the ground. In this way considerable defoliation may take place with a resultant reduction of crop.

(c) ON THE BUDS.—The greatest injury caused by Spur blight is associated with the buds. On young canes, as stated above, the injury is localized mainly at the point of attachment of leaves. As the buds are formed in the axils of the leaves, the buds are directly attacked by the fungus which causes them to become dwarfed, shrivelled and in far too many cases, killed outright. (Fig. 10.)



FIG. 9—Spur blight on leaf (photo by L. W. Koch).



FIG. 10—Effect of spur blight on buds (photo by L. W. Koch).

When infected buds are not killed outright during the fall and winter, they are able to send forth in the spring, only short, weakly spurs with yellowish foliage. Since the buds produced this year become the fruiting spurs for next year, it is readily apparent that spur blight, in reducing the number of healthy buds, directly reduces the crop.

Control

1. For new plantations use only certified stock. Such stock is freer from diseases than ordinary stock.

2. In plantations already affected with spur blight, good control can be effected by spraying. Use Bordeaux mixture 3 : 6 : 40 with the addition of 2 pounds of whale oil soap to every 40 gallons of spray material. Two applications only are necessary. In fact in some seasons one application has been sufficient. The first application should be applied when the sucker plants are 5 inches to 9 inches high. The second application should be applied two weeks later.

3. In spraying, use a fine mist and direct the spray on the young sucker growth using an angle nozzle for best results. Endeavour to completely cover the young canes so that they will be protected from infection from the older affected canes.

4. Avoid the practice of allowing the raspberry rows to become too wide and dense. If rows are too wide and too dense moisture is retained longer and experience has shown that under such conditions the disease is most severe.

5. Do not set out plantations in close proximity to wild varieties as spur blight is also present on wild varieties.

6. Thinning out of badly spur-blighted canes during pruning operations in the fall is to be recommended, provided sufficient canes are left in the stool for next year's crop.

CROWN GALL

Caused by *Pseudomonas tumefaciens* (E. F. Sm. & Towns.) Dugg.

This disease attacks raspberries as well as many other plants, both wild and cultivated, such as apple, pear, plum, peach, apricot, cherry, almond, English walnut, poplar, grape, blackberry, beet, rose, tomatoes and other vegetables, as well as many weeds. Although the evidence of different workers concerning Crown Gall is somewhat conflicting, it is generally considered that Crown Gall may be serious on raspberries. The variety Columbian seems to be very susceptible.

Symptoms

Crown gall is apparent as swellings or tumor-like galls on the crown and underground parts of the plant, although aerial galls are quite common with the raspberry. (Fig. 11.)

Cause

Crown gall is caused by *Pseudomonas tumefaciens* (E. F. Sm. & Towns.) Dugg. The attack of the bacterium results in the large swollen galls which give the disease its name.

Control

1. Never set out plants that show the presence of crown gall.
2. When soil has become infested with the crown gall bacteria, crops attacked by crown gall should not be planted therein for at least three years. In other words, practise crop rotation, using such crops as corn, oats, wheat, etc., which are not susceptible to crown gall.



FIG. 11—Crown gall on raspberry, Columbian variety.

ANTHRACNOSE

Caused by *Plectodiscella veneta* (Speg.) Burkh.

This is a fungous disease and although it attacks both red and black varieties, is severe only on black varieties. Since red varieties are much more commonly grown in Canada than black varieties, Anthracnose does not produce as severe injury to our raspberry growing industry as it would if black varieties were more general. In sections where black varieties are grown, however, Anthracnose is often a very serious disease, perhaps the most destructive the grower has to contend with.

Symptoms

The most striking symptoms are to be found on the canes as grayish spotted areas, with purplish borders. (Fig. 12.) The diseased spots vary in size from $\frac{1}{8}$ th of an inch or more in diameter, to large, irregular blotchy patches, where two or more spots come together and coalesce. As the disease progresses the cane may split. In badly diseased canes the flow of sap and water is greatly hindered by the girdling action of the fungus, and as a result, the fruit fails to develop to its normal size.

On the leaves, less conspicuous spots are present. The spots are similar to those on the cane in that they have a gray centre and purple margin. Often, the infected leaf tissue drops out, leaving a "shot hole" effect. The leaf and fruit stalks as well as the fruit itself may be affected with this disease.



FIG. 12—Anthracnose on black raspberry.

Cause

The fungus which causes this disease is known as *Plectodiscella veneta* (Speg.) Burkh. The spores are produced in the grayish centre of the diseased spots and are distributed by drops of dew or rain, accompanied by air currents. The fungus lives overwinter in the canes, producing in the spring a new crop of spores similar to those produced the past season, as well as a new kind of spore, the so-called ascospore. Both of these types of spores are able to start new infections.

Control

(1) Use certified stock or stock showing no symptoms of the disease. In the case of black raspberries, remove and burn all old parts that remain above the ground after planting.

(2) All fruiting canes should be cut out and burned shortly after fruiting.

(3) Thorough cultivation is to be recommended, since the rows should be kept free of weeds which tend to conserve moisture among the canes.

(4) A spray application of lime sulphur 1 to 9 at the delayed dormant stage is of considerable value in checking spread. In severe cases an additional application of Bordeaux 3 : 6 : 40 with 2 pounds of whale oil soap added to every 40 gallons, should be applied one week before the blossoms open.

In some seasons foliage injury will result from spray applications on raspberries. In wet weather Bordeaux is more apt to cause injury while in hot, dry, sunny weather, lime sulphur is more dangerous to use. In so far as the delayed dormant application is concerned, this should cause no injury. Where a second application is found to be necessary, a week before blossoms open, care should be taken to direct the spray on the young canes only, and to avoid spraying the foliage as much as possible.

STUDIES IN FRUIT DISEASES

I.—Tomato Diseases—by G. H. Berkeley (Bulletin No. 51—New Series Revised Edition).

II.—Diseases of Plums and their Control—by G. H. Berkeley (Pamphlet No. 119)

III.—Diseases of the Raspberry—by G. H. Berkeley (Pamphlet No. 120, New Series—Revised Edition of Pamphlet No. 72, New Series).

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